

Biochar: Saviour of the World or a Load of (Pyrolised) Crap

Paul Munroe

Electron Microscope Unit
University of New South Wales
NSW 2052
Australia
p.munroe@unsw.edu.au

VISIT...

LANZAROTE
Caliente.COM

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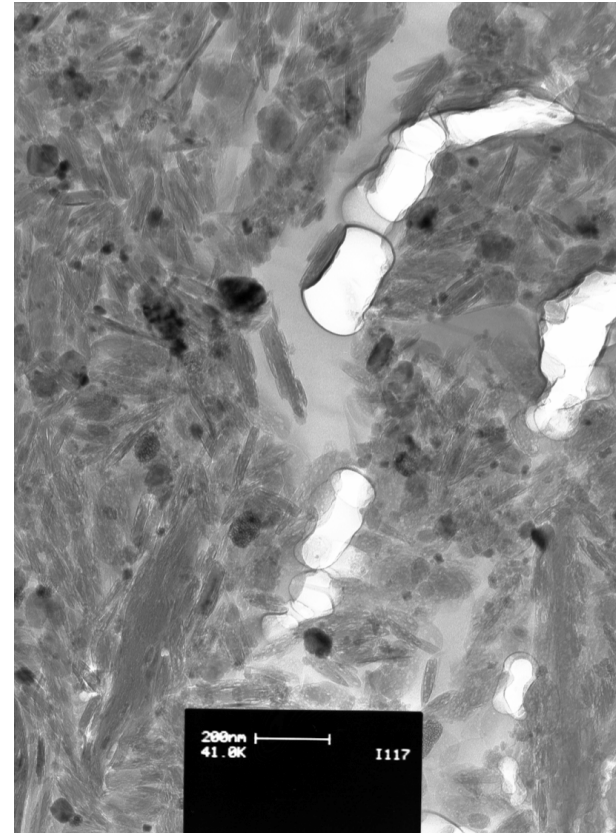
Lukas van Zweiten/Steve Kimber – NSW DPI

.....and any others I am about to misrepresent or plagiarize

Outline



What am I doing here?
Climate change
Biochar
Terra Preta
Benefits of biochar
Carbon accounting/political drivers
Future paths



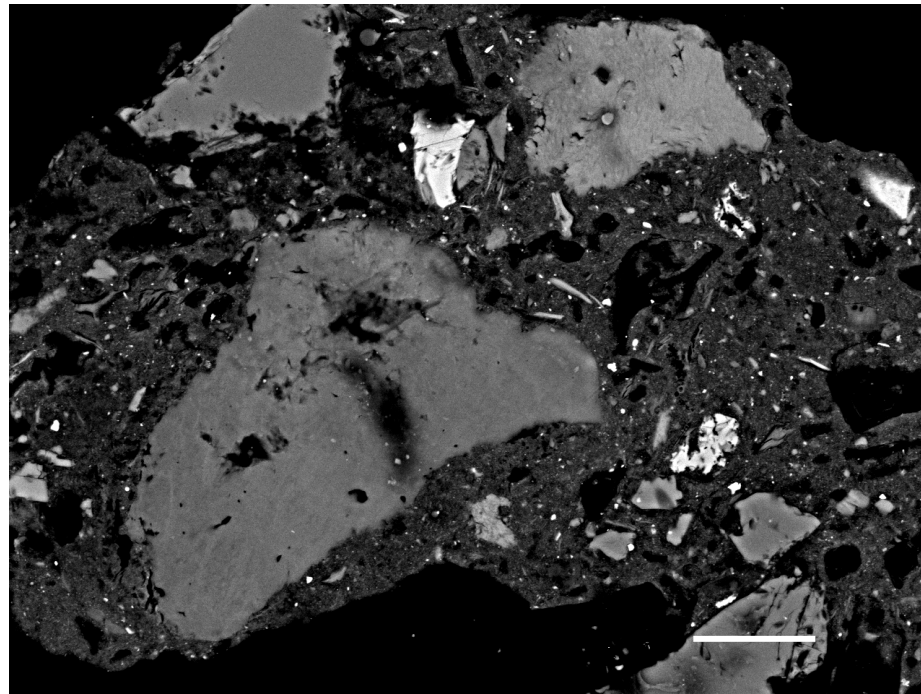
TEM image of Terra Preta

What am I Doing here?



Electron Microscopy (etc) of Biochars

Collaborations with BEST Energies, AnthoTerra, NSW DPI etc



SEM Image of Terra Preta

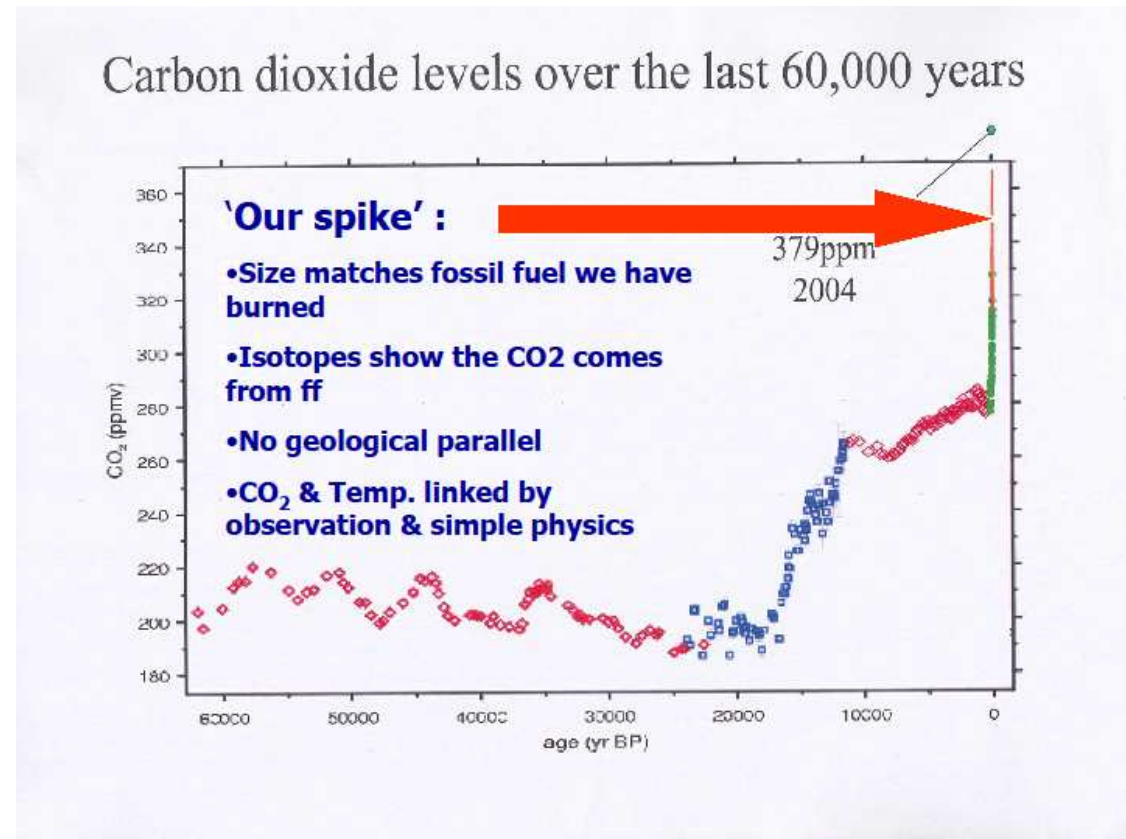
“Burning Down the House”



Historical and physical relationships between CO₂ levels and temperature.

Levels have risen (and are rising) post industrial revolution at 2ppm a year.

Projected increases in temperature have catastrophic consequences



Courtesy Lord Ron Oxburgh – Int. Biochar conf. Sept 2008

CO₂ Levels



- Aim to cap CO₂ levels at 450 ppm
- Increasing 2ppm a year
- Correlation of increase to fossil fuels usage
- Links to climate change
- Other effects – re increase in methane output etc
- Inter-related activities may increase this further



Reducing CO₂ Outputs



Need to sequester carbon (in some form) to reduce/stabilise CO₂ levels.
Could be achieved through either reduction in fossil fuels usage and increased use of alternate energy sources (wind, solar, solar thermal, nuclear? etc etc)
Removal and storage of carbon from coal fired power stations (Clean Coal!?)
Other means of storing carbon (biomass, biochars, algae etc)



The solar thermal furnace in the Pyrenees

Formed by pyrolysis of biomass (heating in absence of oxygen) – usually biowaste*
Generates gas/liquid fuel (syngas) and solid biochar.
Biochar is charcoal-like (C-rich) material which can be used as a soil amendment and act as means of sequestering carbon.

Biochar may represent the single most important initiative for humanity's environmental future. The biochar approach provides a uniquely powerful solution, for it allows us to address food security, the fuel crisis, and the climate problem, and all in an immensely practical manner – Tim Flannery – 2008

* Does biochar by definition have to come from sustainable sources?

Biochar Production



Biochar is made by heating biomass under oxygen-limited conditions (e.g. pyrolysis). Biomass feedstocks can include forestry and agricultural waste products, municipal greenwaste, animal manure, some industrial wastes such as papermill wastes. The thermo-chemical conversion drives off the volatile components of the biomass and stabilises the remaining carbon into a black, highly aromatic solid.



Demonstration plants etc at BEST Energies involve throughput of several hundred kg per hour - Yield of Char 30-35%

Char Types



The chemical and physical properties of biochar are controlled both by choice of feedstock and process conditions (e.g temperature, residence time, heating rate and feedstock preparation).

These properties affect the interactions of biochar with the environment during application.

Research on matching the unique properties of biochars to specific applications is ongoing.

There is no rapid screening technique currently available that provides the means for biochar products to be compared or matched to a particular use



Solutions can be found through biochars.

Biowaste (e.g chicken manure, papermill-sludge) subject to pyrolysis - ideally at source (e.g chicken farm), so avoids high transport costs etc

Pyrolysis creates syngas/biofuel (used locally for heat/power on the farm)

Biochar is dry (lightweight and easy to transport) and acts as powerful fertilizer/soil amendment.

Can be applied close to the point of production

Promotes plant growth, (higher crop yields etc), and remains stable in soil.

Increases the carbon content of the soil, improves soil health, water retention.

Carbon is sequestered in soil - not adding to CO₂ levels in atmosphere

See video at

<http://www.venearth.com/index.html>



Terra Preta



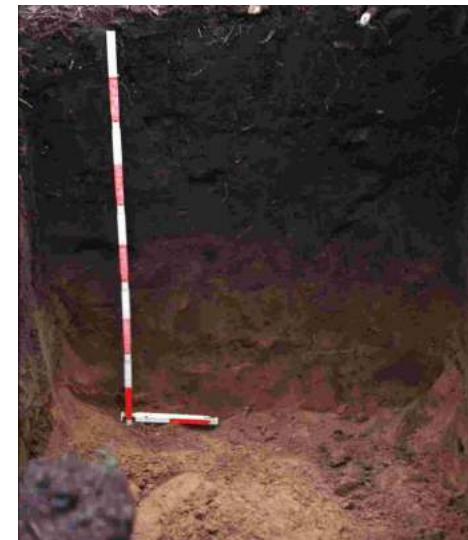
Terra Preta is a rich anthropogenic soil found in the Amazon basin. It was created by the Amazonian Indians by the mixing of charcoals, animal waste, broken pottery etc.

Terra Preta is not a biochar, but an example of a biochar enriched soil.

Terra Preta found also in Australia



‘normal’ soil



“Terra Preta”

Studies of charcoal from natural fire and Terra Preta etc indicate millennial-scale stability. However, the stability of contemporary biochar products is unknown. It is difficult to establish the half life via short term experiments.

Limited data suggest that turnover time of biochar ranges from decades to centuries, depending on feedstock and process conditions. At the moment there is no established method to artificially age biochar and assess likely long term stability.



Agronomic Benefits



Studies have shown that biochar application has shown significant agronomic benefits. However, these results are NOT universal as some studies have shown no enhancement

This is because of the wide range of properties between different biochars, and variation in impact due to interaction with different soil and crop types. In some cases biochar promotion of plant growth requires addition of 'NPK'

Further studies are required to determine what biochar characteristics best promote plant growth.



Effect of Biochars on Plant Growth

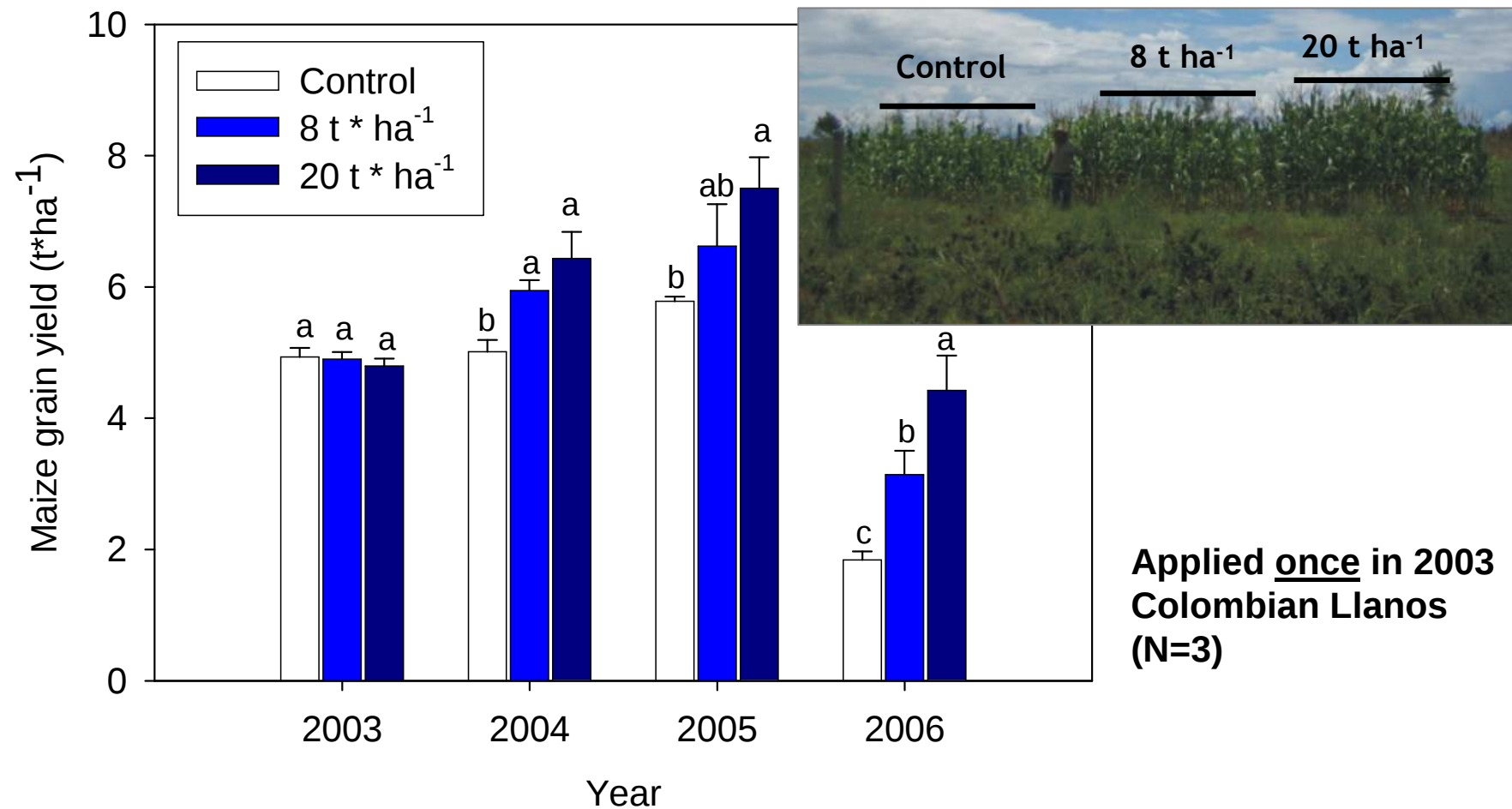


Corn crops - on left without biochar; on right with biochar



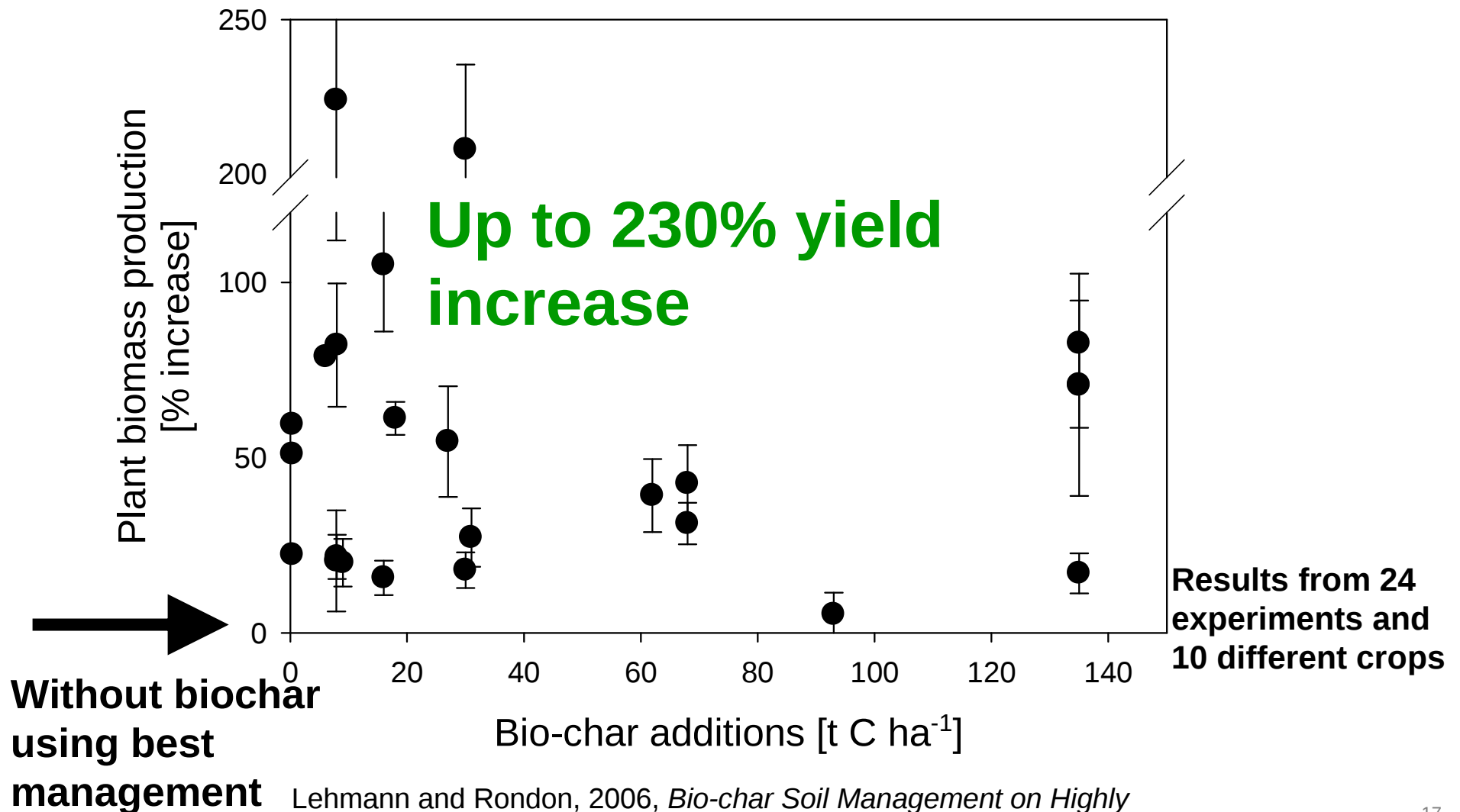
From S. Kimber, L. van Zweiten, NSW DPI

Biochar: Soil Improver Colombia



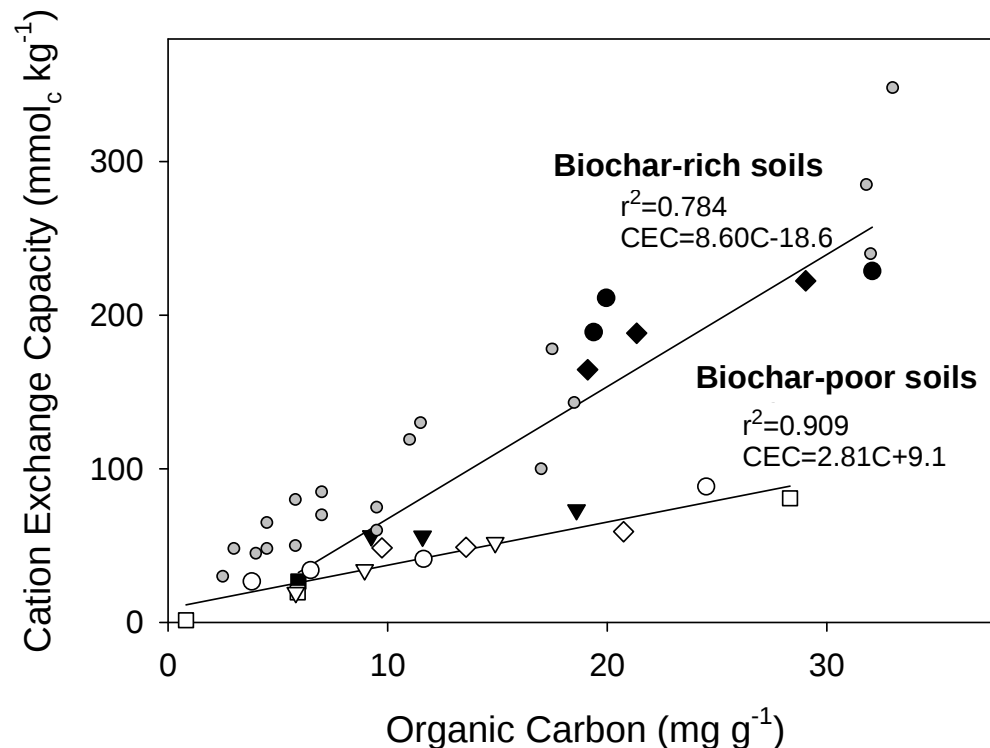
Major, Lehmann, Rondon, unpubl. data

Biochar: Soil Improver



Lehmann and Rondon, 2006, *Bio-char Soil Management on Highly Weathered Soils in the Humid Tropics*. Francis and Taylor, FL

Biochar Soil Improver - Why?

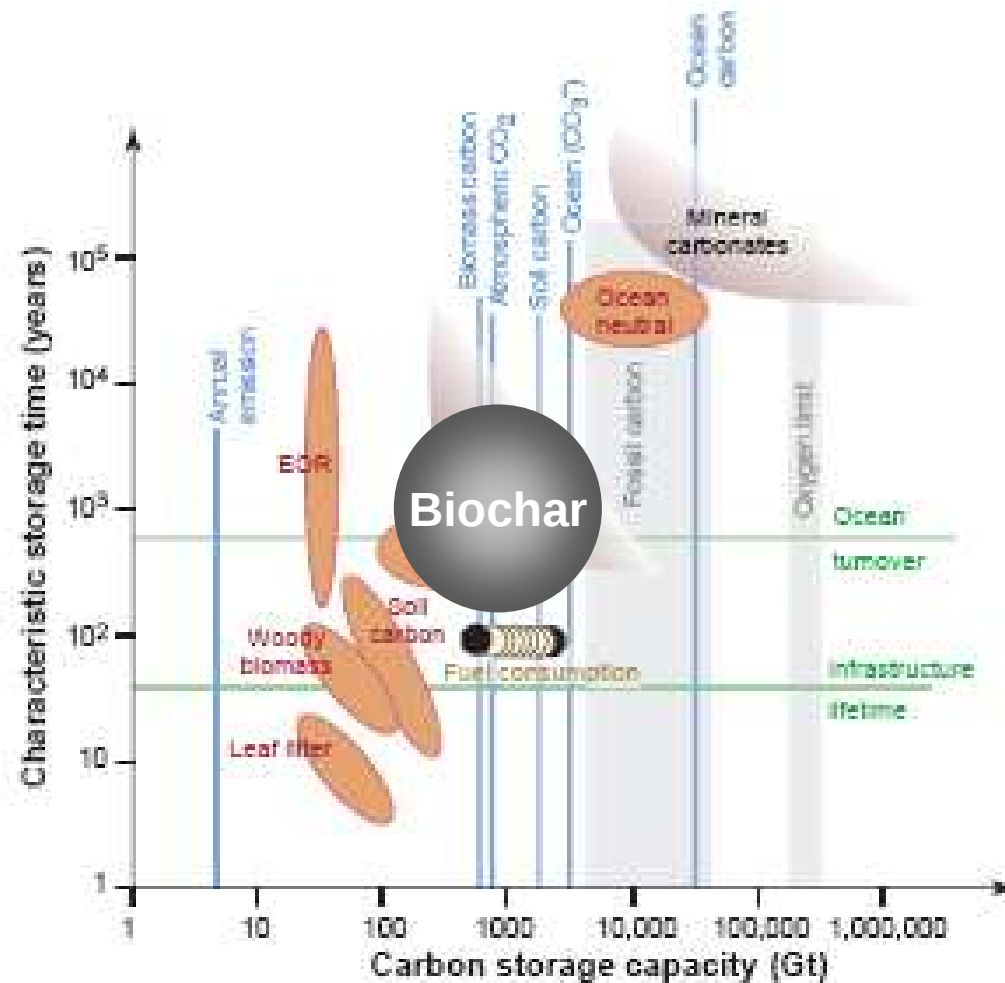


Biochar is shown to improve cation exchange capacity.

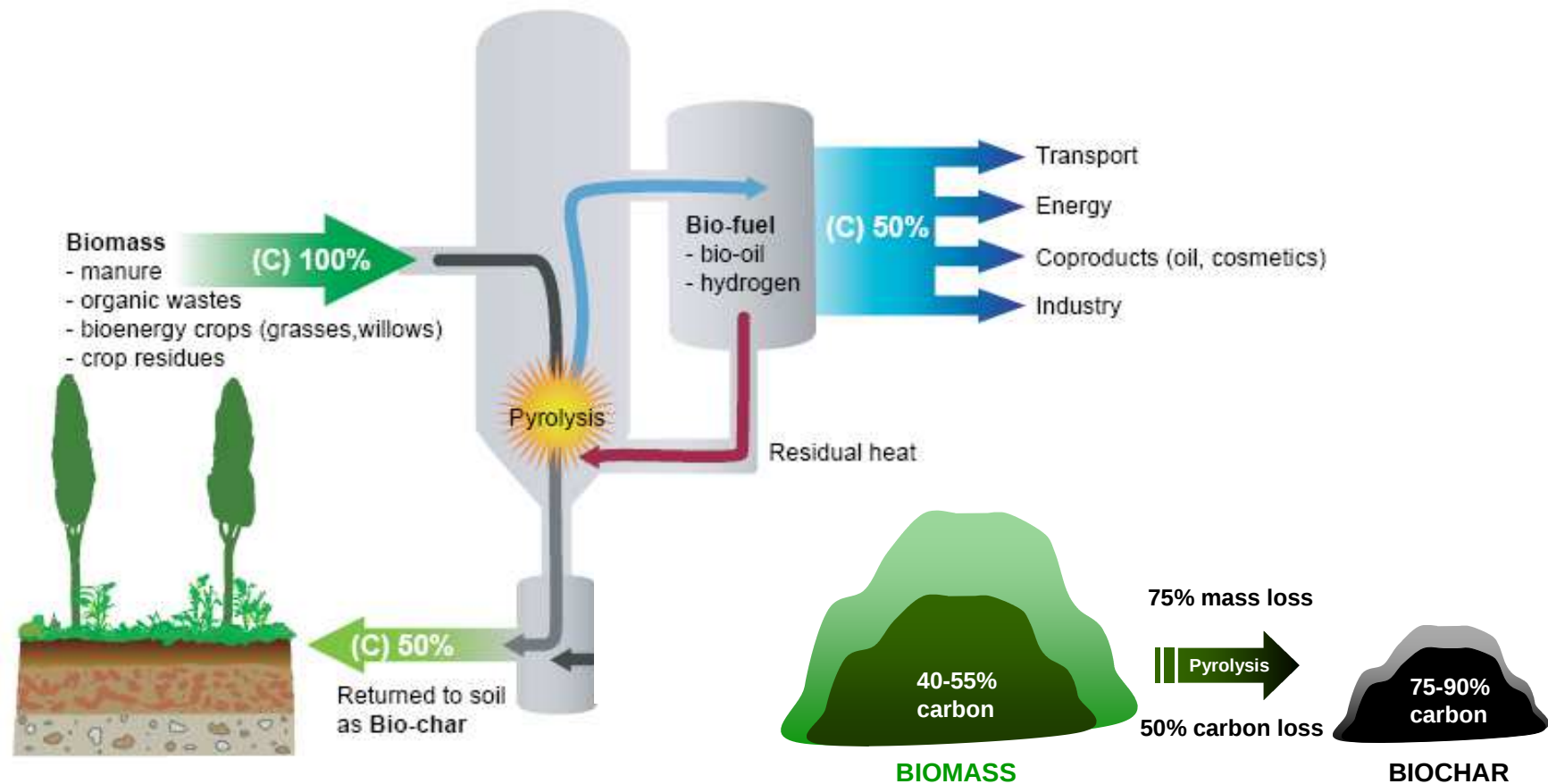
Porous structure of biochars thought to play significant role

Interfacial reactions between clays and carbon may involve electrochemical interactions

Carbon **withdrawal** from the atmosphere

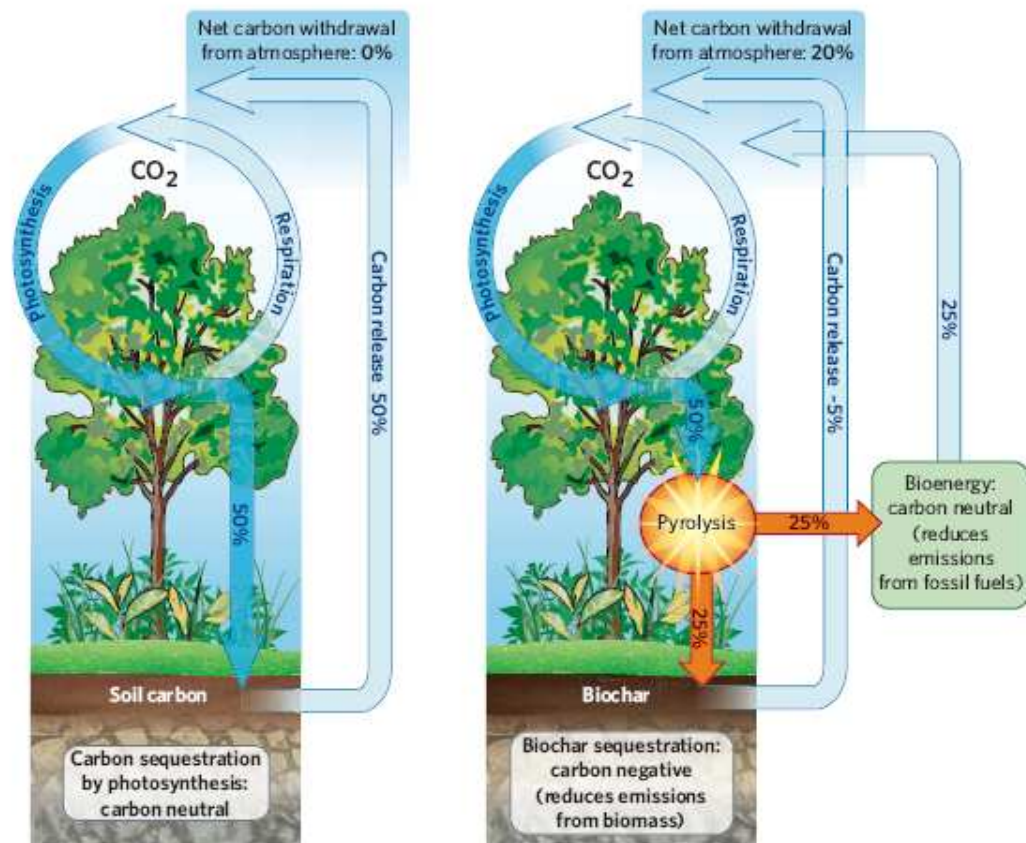


Biochar = carbon-rich residue of heating biomass without oxygen



Lehmann, 2007, *Frontiers in Ecology and the Environment* 7, 381-387

Biochar = slowing down the rapid biological return of CO₂



Lehmann, 2007, *Nature* 447: 143-144

Biochar Sustainability Benefits: Third World Applications

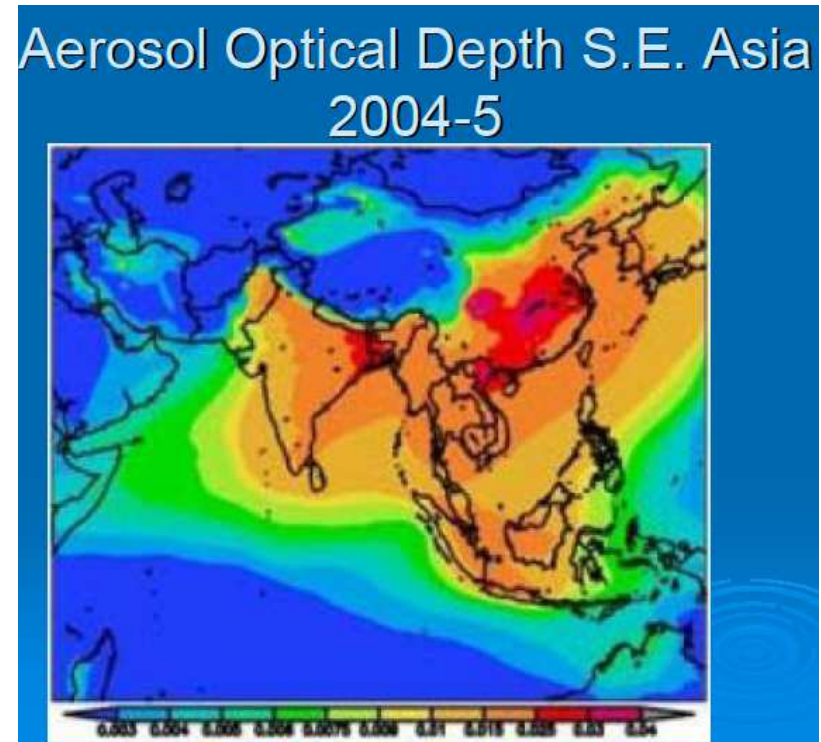


Massive increases in 3rd world population and industrialization in China, India, Brazil, Indonesia etc.

Increases in CO₂ production through industrial output (e.g. coal-fired power stations).

Increases in emission of soot particulates through cooking on open fires etc, leading to tropospheric warming (~ 1.5M people die each year due to open fire cooking)

Expansion in agricultural activity leading to decreases in soil quality, increase in volumes of biowaste.

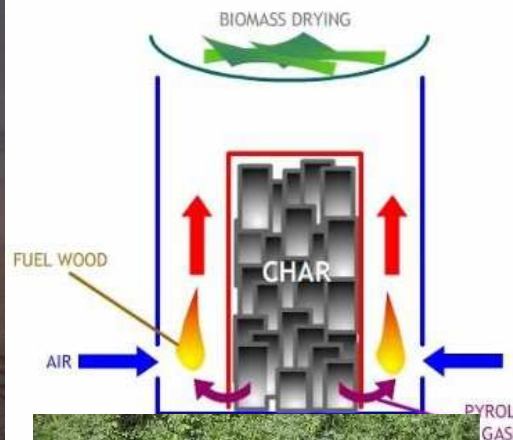


Courtesy Lord Ron Oxburgh – Int. Biochar conf. Sept 2008

Biochar Sustainability Benefits: Third World Applications



Lower indoor pollution reduces respiratory illness,
eye infections, death associated with indoor heating etc
Provides more efficient form of heating. cooking etc



Biochar production may provide effective solutions in 3rd world through local sources of biochar production

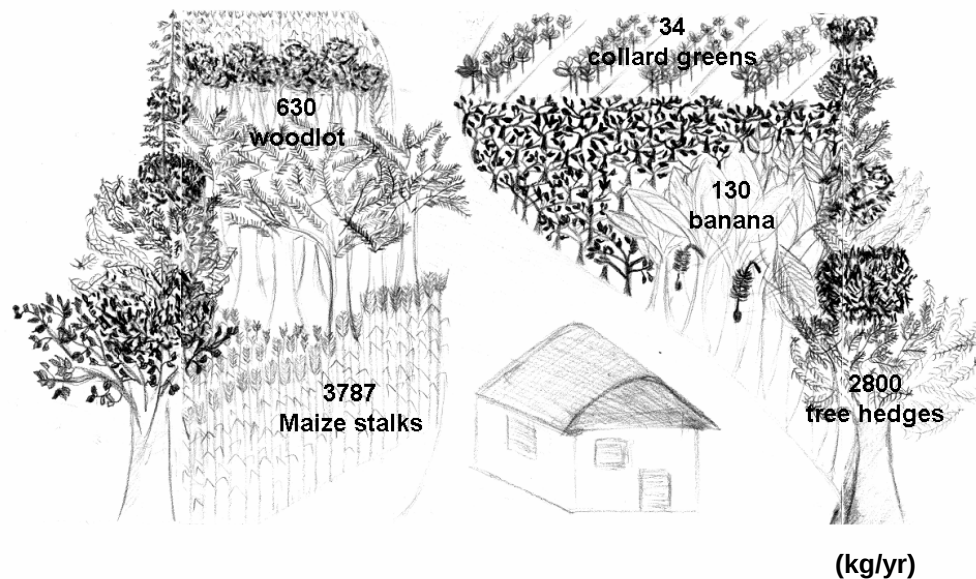
A village may operate its own biochar reactor, using local sustainable sources of biowaste (from nearby agricultural activities). The biofuel generated may act as a local source of electricity etc in the village and the biochar may be used to local crop production etc

Would need reactors to be ‘affordable’

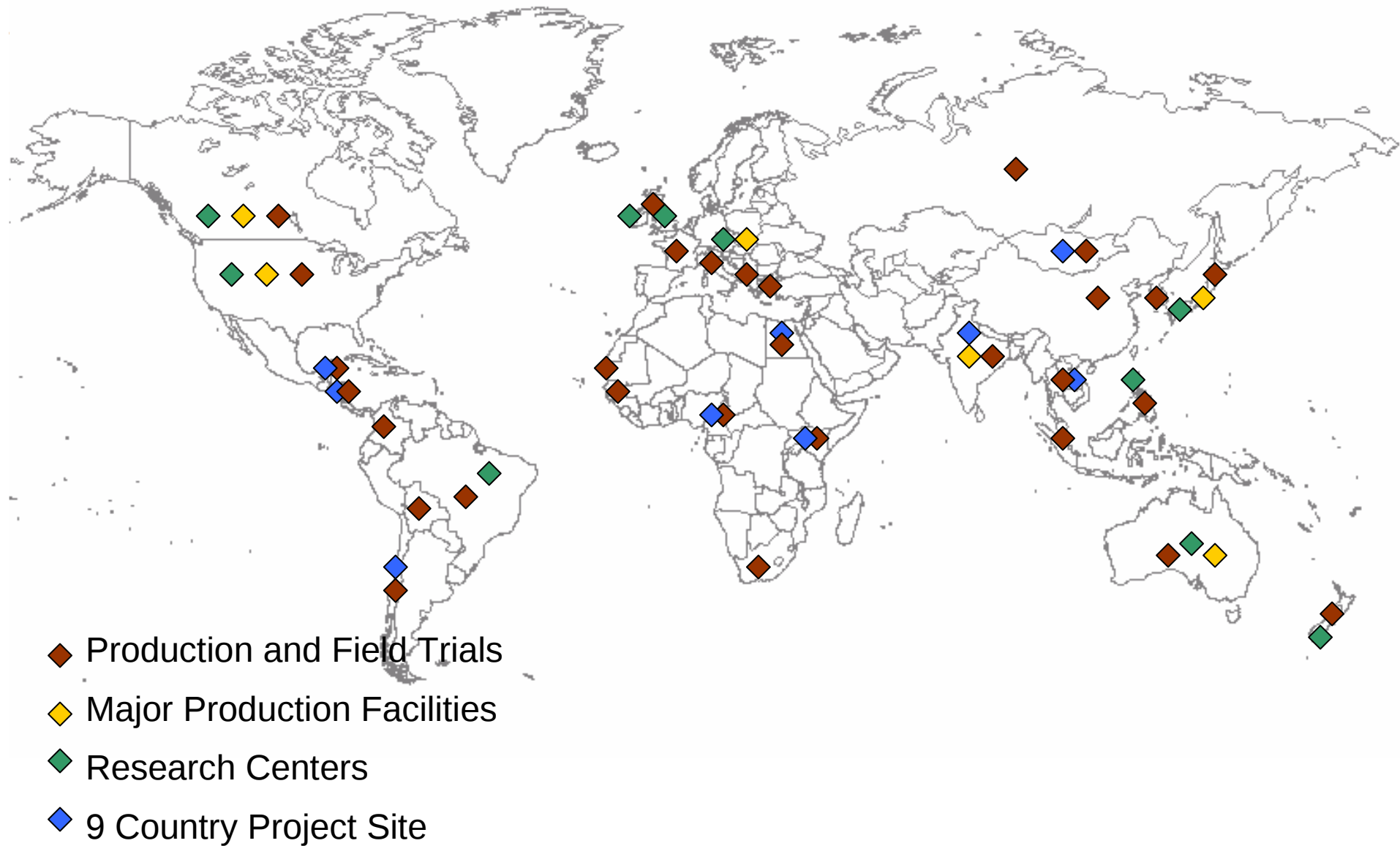


Fuel diversification:

- Fuel security
- Lower fuel acquisition time

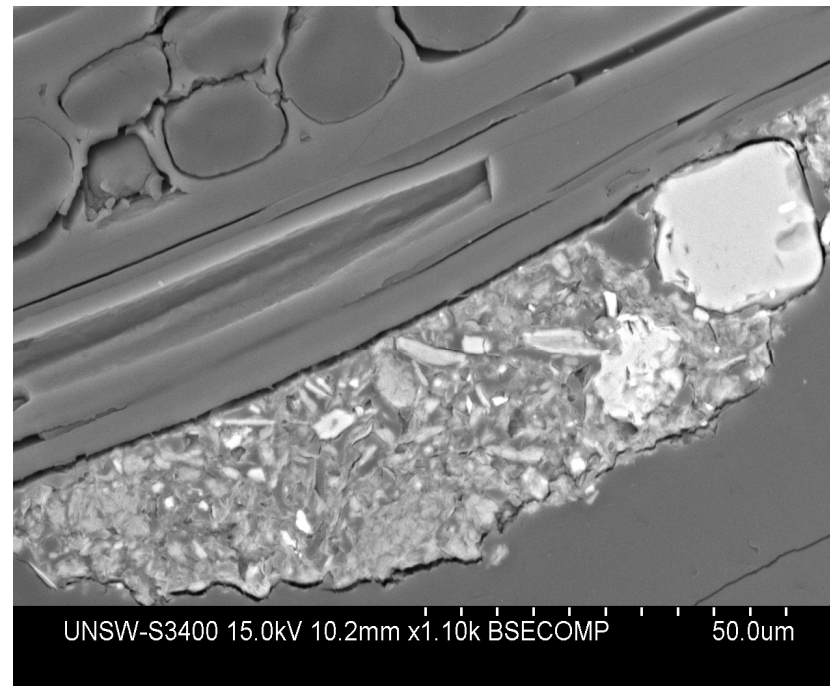


Global Biochar Production, Utilization, and Research

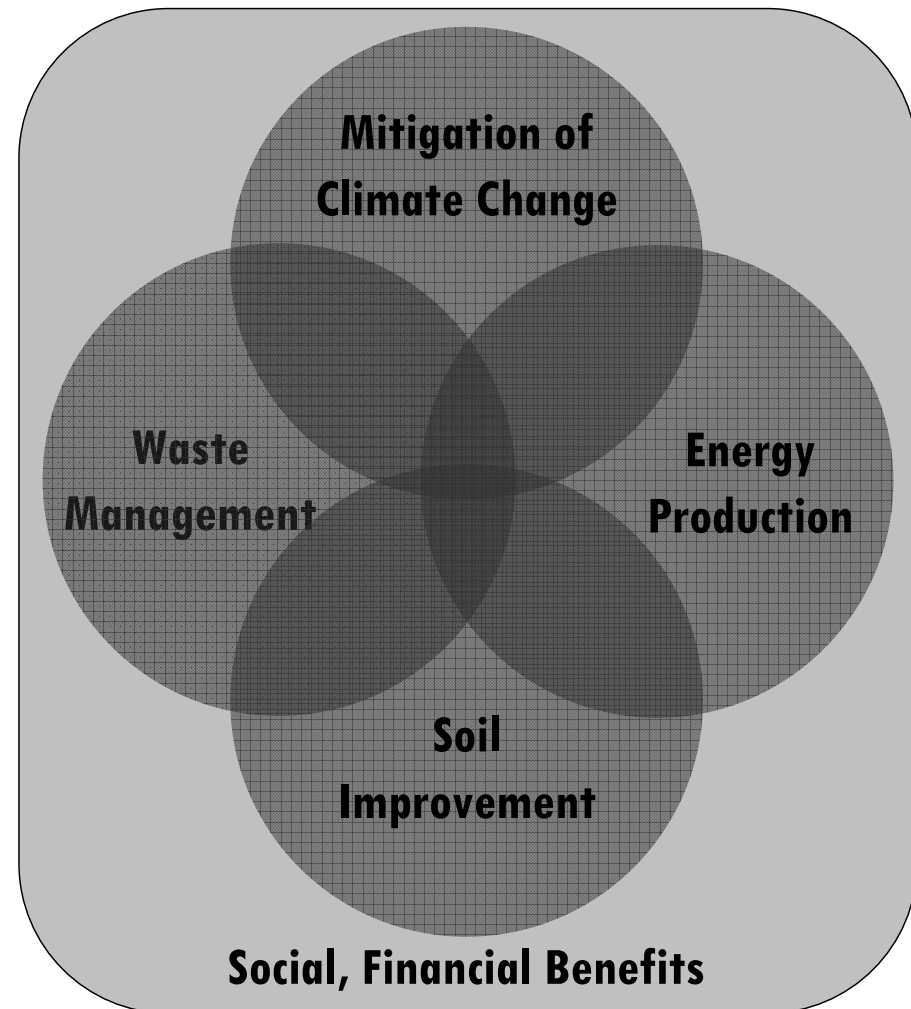


At UNSW we have been examining how to re-create the Terra Preta soils artificially. Involves mixture of chicken waste, saw dust, kiln dust etc heated to low temps. Preliminary lab-scale results indicate microstructures similar to Amazonian Terra Preta and enhanced agronomic activity. Upscale trails (with Dept Agriculture in WA) to larger field trials

SEM Image of
Synthetic Terra Preta



1. **Atmospheric CO₂ can be sequestered as biochar in soils for long periods of time**
2. **It does not pose a storage risk but an opportunity to improve natural resources and support agricultural sustainability**
3. **It can (but does not have to be) combined with energy generation and waste management**



What are the likely benefits of biochar?



In some soil types and with certain crop species, some biochars can:

- increase water holding capacity of the soil
- increase biomass (crop) production
- increase soil carbon levels
- increase soil pH
- decrease aluminium toxicity
- decrease emissions from soil of the greenhouse gases CO₂, N₂O and CH₄
- improve soil conditions for earthworm populations
- increase cation exchange, especially over the long-term
- improve fertiliser use efficiency

In a wide variety of biochar feedstock materials, process conditions and applications leads to a huge and diverse range of responses that are often contradictory. Studies suggest that the greatest positive effects of biochar applications have been in highly degraded, acidic or nutrient-depleted soils.

Thus, biochar research is of particular relevance in the Australian context, as many Australian soils exhibit very low nutrient and carbon levels, and are at risk of acidification.

Biochar must be an economically attractive alternative.

This economic attractiveness could arise from a combination of:

- valuable energy commodity yields
- value arising from biochar as a soil additive
- valuable greenhouse gas (GHG) offsets

generated by offsetting fossil fuels, reducing emissions from use of agricultural inputs and sequestering carbon (C)

There are currently a number of models being used to assess economic viability. Require further refinement – depend heavily on biochar being included in Emissions trading schemes etc



1. Biochar system analysis at scale of implementation
2. Biochar handling and application
3. Monitoring and quality control of biochar ("rapid tests")
4. Biological effects (both as carrier for beneficial microorganisms as well as risk)

EVALUATION IN CONCERT WITH IMPLEMENTATION

1. As a soil amendment that sequesters carbon and enhances soils, biochar clearly “fits” within the Land Use, Land Use Change and Forestry (LULUCF) context of the UNFCCC Kyoto Protocol
2. Article 3.4 of Kyoto Protocol allows countries to account for changes in carbon stocks arising from additional human-induced activities in agricultural soils (“soil carbon management”) and LUCF
3. Biochar at COP-14 in Poznan, Poland:
 - Submissions of ‘Ideas and Proposals on Paragraph 1 of the Bali Action Plan’ were accepted by the Ad Hoc Working Group on Long-Term Cooperative Action (AWG-LCA) Under the Convention
 - The assembled document *will provide the basis for the Post-2012 agenda to be negotiated in Copenhagen (7-18 Dec. 2009)*

1. 3 Submissions on Biochar made through various UN Climate Change groups:

- Micronesia, UNCCD, Clean Air Task Force/IBI

2. UNCCD, CATF/IBI submissions:

- Biochar: mitigation and adaptation tool; seeking Clean Development Mechanism (CDM) eligibility
- Strong link between 3 Rio Conventions
 - Climate change
 - Desertification
 - Biodiversity



Five year project to develop a common scheme to build, test and evaluate the construction needs, cooking quality, dissemination requirements, environmental/climate impacts of pyrolysis unit production and biochar application. Provide access to an international network creating biochar projects, worldwide

Common project elements include, not limited to:

Project scoping: Feasibility studies and assessments of the potential for pyrolytic cook-stoves, kilns and biochar production

Pyrolytic cook-stove and kiln development: Design, development, and optimization of the clean burning, pyrolytic cook-stoves and kilns, including emissions testing, indoor air quality, and health status.

Stove/kiln and biochar adoption: Implementation and monitoring of the performance of cook-stoves and kilns, biochar production, application to field soils.

Biochar analyses: Characterization of the biochar and the associated crop responses.

Greenhouse gas emissions and carbon offsets.



International Biochar Initiative:

<http://www.biochar-international.org/>

Australia and New Zealand Biochar Researchers Newwork:

<http://www.anzbiochar.org/links.html>

BEST Energies:

<http://www.bestenergies.com/>

“Biochar for Environmental Management”, eds J. Lehmann and S. Joseph, Earthscan Publications; ISBN: 978-1-84407-658-1

Biochar Conference – Gold Coast, May 17-20, 2009

Biochar is produced through pyrolysis of biomass (along with biofuels)

Strong evidence to show biochar is effective as a soil amendment

Evidence to show it can act as a means for long term sequestration of C

Currently too much “parameter space” to understand how to optimise biochar

Need to conduct widescale trials (involving upscaling of production and application)

Economic uptake is promising, but foundering under uncertainty over ETS etc

Biochar Production Systems



3R Vacuum Pyrolysis Kiln



Gasifier modified to produce biochar from chicken manure

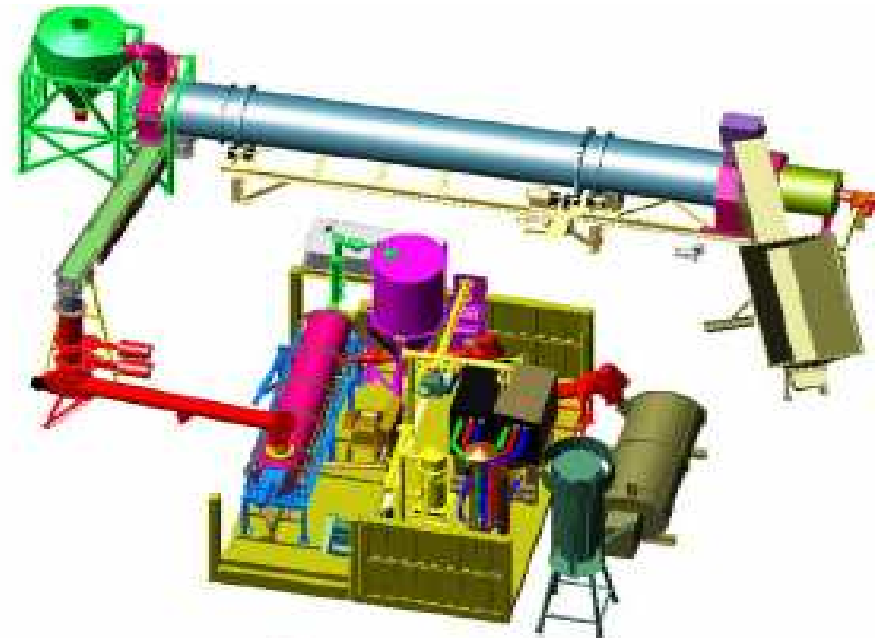


Kansai Kiln for Rice Husks and Sawdust



Dynamotive
Fast Pyrolysis
Plant Ontario
Canada





- Throughput 300 - 500kg/hr
- Yield of Char 30-35%

